Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

The Faculty of Natural Resources and Agricultural Sciences

New Blend product

–Development of a product recipe

Sofia Wänerskär

Department of Food Science
Master´s thesis • 30,0 hec • Second cycle, A2E
Food - Innovation and Market • Publikation/Sveriges Lantbruksuniversitet, Institutionen för Livsmedelsvetenskap: 359
Sweden 2012

New Blend product

Sofia Wänerskär

Supervisor: Paresh Dutta, SLU,
Department of Food Science
Assistant Supervisor: Pirjo Björkenbacke,

Examiner: Lena Dimberg, SLU,
Department of Food Science

Credits: 30,0 hec
Level: Second cycle, A2E
Course title: Independent Project in Food Science - Master's Thesis
Course code: EX0396
Programme/education: Food - Innovation and Market

Place of publication: Sweden
Year of publication: 2012
Title of series: no: Publikation/Sveriges Lantbruksuniversitet, Institutionen för Livsmedelsvetenskap: 359
Online publication: http://stud.epsilon.slu.se

Key Words: Butter flavour, Hardness, Fat

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

The Faculty of Natural Resources and Agricultural Sciences
Department of Food Science

Abstract

Milk fat is getting more and more expensive and the demand for natural products is increasing. The combination of increased milk price and larger demands from consumers result in that a dairy food company wants to offer consumers a natural blended spread product with excellent butter flavour.

A project to develop a recipe for such a product has been carried out. Based on the literature and the company's collective knowledge of the properties of fats pilot runs for testing various recipes, sensory, chemical and bacteriological assessments of the pilot-produced products and test baking with the products was made. The results from the different experiments were analysed statistically by multivariate data analysis.

Two days conducted for experiments at pilot plant resulted in six different products with different ratios of vegetable fat and butterfat as well as different ratios of fractionated fat. The changing of the type of fat in the product was done to get a product with the right taste, hardness and other desired properties. After sensory, bacteriological, chemical and baking analysis of the products it was seen that one of the products was better than the others when comparing it to the reference products used.

The project has resulted in a product recipe to work on to see if the product is to pack in foil. If a product with the same characteristics as reference product one is to be developed it is probably needed to fraction the fat or to ad a stabilizer/emulsifier as this will flatten the melting curve and particularly increase the proportion of solid fat at the higher temperatures. Moreover, it is important not to flatten the fat melting curve too much as it means a risk that odd flavour appears in the cakes baked on the product.

Keywords: butter flavour, hardness, fat

Table of Contents

1 Introduction

1.1 Background

Today the milk fat is getting more and more expensive, which means that consumers are looking for alternative fats. They are at the same time looking for cheaper products and natural products, which is a difficult combination. A dairy food company wants to offer these consumers a cheaper product where the good butter flavour is maintained in a natural blend product (milk fat/vegetable fat) without additives and chemically produced fats.

1.2 Purpose and objectives

The purpose of the project was to develop a recipe for a new blend product (milk fat/vegetable fat), a solid shortening, wrapped in foil, with x % butterfat, which makes it cheaper than pure butter, but still have the good taste of butter. The objectives were also to determine how much butterfat is needed to provide the optimum butter flavour.

A sub objective was to collect literature on what influences different properties of fats, to conduct pilot experiments to produce blend products from different recipes, to conduct baking tests and sensory analysis on products from the pilot experiments and reference products in order to see how the different fats works in the baking process and which differences in butter taste they give rise to in the baked goods.

1.3 Boundaries

The project includes pilot experiments at a dairy food company's production plant for butter and spreads. Perfector technique is used. Blend technique is not included. Reference products are Milda and Milda Gold in foil and Salted Swedish Butter, referred to as reference one, two and three in the study. The milk fat will partly be substituted with rapeseed oil. There will not be any palm oil, aromas or lecithin in the product ingredients.

2 Method

2.1 Literature study

Scientific papers on the subject of sensory analysis, baking quality of fat, and fractionation of fat were searched for in the databases Web of Knowledge, Scopus and Science Direct. Other literature was searched for in the SLU Libraries database LUKAS and the overall Swedish library database LIBRIS. Previous studies at the plant in the dairy company were read as well as instructions and procedures of the quality database ADAMS. In addition, literature and expertise from employees of the dairy food company were provided.

2.2 Practical work

Experiments at Pilot Plant were conducted and the products were analyzed fresh, after three weeks and after ten weeks according to Table 1. The products were further tested for their baking properties by baking rolled and cut shortbread, cinnamon rolls and sponge cakes. The baked goods were analyzed sensory and compared with the same products baked with *Swedish Butter*, *Milda* and *Milda Gold*. Also during the baking process the different fat properties were assessed. Times and products tested for baking properties can be seen in Table 2.

Table 1. Assessment scheme

Fresh	3 weeks	10 weeks
Bacteriology	Properties	Bacteriology
Chemistry	- Sensory analysis of baked goods	Chemistry
	Sensory analysis of fats	Sensory analysis of fats
	- development panel	- development panel
	- specialist panel	- specialist panel

(Source: ADAMS, 2005)

Table 2. Times and products tested for baking properties.

	Products tested	Identification of bakery
week 14	12074-1 Reference product 1	12074-1
	12074-2 Reference product 2	12074-2
	12075-1 Reference product 3	12075-1
week 18	12104-1	12104-1
	12104-2	12104-2
	12104-3	12104-3
	12104-4 Reference product 3	12104-4
week 24	12144-1	12144-1
	12144-2	12144-2
	12144-3	12144-3
	12144-4 Fractionated butter	12144-4
	12144-6 Reference product 3	12144-4

2.2.1 Production of the lipid blends

Two days were allocated for experiments at Pilot Plant. On the first day three different recipes with *x* % total fat and different percentage of milk fat were tested to see which recipe gave the best product. The mix of milk fat and vegetable fat can be seen in Table 3 and the settings in Appendix 1 (Process settings). The experiments were conducted at a perfector[1] plant. The product was filled in cups of 250 g and 40 cups per recipe, sealed with a welded foil and lid and placed in the refrigerator.

[1] Perfector technique is the technique used making margarine

Table 3. Mix of milk fat and vegetable fat in the different recipes of Pilot Plant experiment one.

Recipe	Milk fat/Vegetable fat	Milk fat of emulsion
12104-1	high in milk fat/low in vegetable fat	high
12104-2	intermedient in milk fat and in vegetable fat	intermedient
12104-3	low in milk fat/high in vegetable fat	low

The testing of the products from day one showed that the recipe 12104-2 was better than the others based on the results from the production of baked goods. The experiments of day two were based on the best recipe from day one (12104-2). Also on the second day three different recipes were tested to see which recipe gave the best product. The parameter that was changed this time was fractionated butter; the settings can be seen in Appendix 1 (Process settings). The milk fat/vegetable fat ratio was held constant and the amount of fractionated fat[2] decreased during the test. The experiments were conducted at a perfector plant. The product was filled in cups of 250 g and 40 cups per recipe, sealed with a welded foil and lid and placed in the refrigerator.

2.2.1.1 Production at perfector plant

The production of the lipid blends were conducted at a perfector plant by mixing anhydrous milk fat (AMF = butter oil) and vegetable oil into a fat phase and then mixing it with a water phase including the rest of the ingredients. The mixing of the two phases resulted in an emulsion which then were pasteurized in a plate heat exchanger and finally chilled, while being worked in special scraped-surface coolers and pin rotors before the filling into cups. The presence of AMF and buttermilk gives the product a butterlike aroma.

2.2.2 Production of baking products

To identify the different characteristics of the spreads they were used in producing the following products:

- Shortbread with egg
  - Rolled
  - Cut
- Sponge cake
- Cinnamon rolls

[2] Butter divided into fractions with differnt melting points, the fractions giving desired melting properties are used.

The different recipes can be seen in Appendix 2 – Recipes of baked goods. In the baking of shortbread a food processor were used. The ingredients were put in the food processor with the fat at top (flour, sugar, egg and fat). The fat was diced and distributed evenly in the bowl. The food processor was run at speed seven (scale 1-14) to a uniform dough. The dough was divided into two equal parts. Part one was rolled to four centimetres in diameter and the second part were plated out to approximately 10cm x 11cm. Both parts were wrapped in plastic and placed in the refrigerator overnight before they were baked as cut cakes brushed with egg respectively rolled hearts.

For the sponge cake an electric whisk were used and the eggs and sugar were whisked for 30 seconds at speed three (scale 1-3). The remaining ingredients were gently stirred down with the help of a spatula. The cakes were baked in rectangular tins of approximately 1.5 litres.

In the baking of cinnamon rolls the fat were melted over medium heat (5 in a scale of 1-9), mixed with milk and heated to 36°C. The yeast was dissolved in the milk/fat mixture and then sugar and about 680 grams of flour were added. The dough was worked about six minutes in the kitchen aid to speed B (scale A-C). Salt were added and the dough was worked for five minutes further. The dough was covered to ferment before it was baked. The filling was mixed with a spoon when 17 minutes remained of the fermentation and were put in room temperature until used. The dough was divided into three parts and rolled out to 30cm x 45cm. The filling was spread on and the dough was rolled up and cut into 15 pieces á three centimetres. The buns were panned and proofed after which they were brushed with beaten egg before being baked.

The baking of pastries was performed in Siemens oven (not convection oven). During the baking process different properties were assessed. The properties can be seen in Table 4.

Observations made during the baking process were collected and analyzed using mean, graphs and the statistic programme Simca. Help were provided from the collective experience in the company.

Table 4. Properties assessed during the baking process.

Melting of the fat	Rolled shortbread	Cut shortbread	Sponge cake	Cinnamon rolls
Time to cook	Time to smooth dough	Time to smooth dough	Volume	Amount flour used
Total melt time	Rolling properties		Height	Rolling properties
Spattering (number of drops)	Stuck in the bench	Stuck in the bench	Time in oven	Fermentation in bowl
Colour	Sticky surface	Sticky surface	Easiness to turn out the cake	Fermentation on baking tray
Foaming	Easiness to cut up rolls	First stretching		Dough consistency
	Ease of brush with egg	Later stretching		Mixing of the filling
	Maintained shape during baking	Adhesion of the plastic		Distribution of the filling - spreading - curling of dough
		Maintained shape during baking		Rolling and cutting the dough
				Rendering of fat

2.2.3 Sensory analysis

The fats from the different experiments were sensory analysed in two different panels called development panel and specialist panel. The specialist panel was a profile panel and consisted of trained assessors conducting descriptive tests of the products and the development panel made assessments according to set criteria on a nine-point scale (Table 5). The development panel assessed the surface appearance, cut surface, water drop, spreadability, hardness and salt and butter taste. These assessments were made after three and also after ten weeks.

Table 5. A 9-point scale used of the development panel

Quality classes	9-point scale applied to the product description
Perfect	9
According to product description	8
Weak errors	7 6
Distinct errors	5 4
Strong errors	3 2 1

(Source: ADAMS, 2005)

The goods baked from the different fats were sensory analyzed in a panel of four assessors. The assessments were not graded in relation to criteria provided for the product but on the perceived intensity/strength of the sample.

Assessments made by the panels were collected and analyzed using mean, graphs and the statistic programme Simca. Help were provided from the collective experience in the company.

2.2.4 Bacterial analysis

The analytical methods used for the bacterial analysis of the fats can be seen in Table 6.

Table 6. Analytical methods - bacteriology

	Analytical method	Reference
Yeast	CGY	ISO 6611:2004(E) / IDF 94:2004 (E): Milk and milkproducts – Enumeration of colony-forming units of yeast and/or moulds – Colony count technique at 25 °C
Mould	CGY	ISO 6611:2004(E) / IDF 94:2004 (E): Milk and milkproducts – Enumeration of colony-forming units of yeast and/or moulds – Colony count technique at 25 °C
Total number of	PCA Sugar free	ISO 13559:2002(E) /IDF 153:2002(E) Butter, fermented milks and fresh cheese – Enumeration of contaminating microorganisms – Colony count technique at 30 °C
Coli forms	VRA	ISO 4832:2006(E) Microbiology of food and animal feeding stuffs – Horizontal method for enumeration of coliforms – Colony count technique

(Source: ADAMS, 2010)

2.2.5 Chemical analysis

Chemically the fat products were tested for percentage of salt, pH-value, percentage of water, hardness at eight respectively 14 degrees Celsius, solid fat content (at five, ten, 20, 30 and 35 degrees Celsius) and percentage of fat. The methods used for the different chemical analysis can be seen in Table 7.

Table 7. Analytical methods - chemistry

	Analytical method	Reference
Salt content	Titration	ISO 15648:2004(E) / IDF 179:2004(E) Butter – Determination of salt content - Potentiometric method
pH-value	pH-meter	ISO 7238:2004(E) / IDF 104:2004(E) – butter, determination of the pH serum. Potentiometric method
Water content	Desiccator	ISO 3727-1:2001(E) / IDF 80-1:2001(E) Butter – Determination of moisture, non-fat solids and fat contents (Part 1 Determination of moisture content) ISO 8851-1:2004(E) Butter – Determination of moisture, non-fat solids and fat contents (Routine Methods) – Part: Determination of moisture content (Regulation EG 213/2001)
Hardness	Stevens QTS	
Solid fat content (SFC)		ISO 8929:1991(E) Animal and vegetable fats and oils – Determination of solid fat content – Pulsed nuclear magnetic resonance method AOCS Official Method Cd 16b-93 SFC by Low-Resolution Nuclear Magnetic Resonance
Fat content	Regulation	Regulation EG 213/2001

(Source: ADAMS, 2010)

3 Theoretical background

3.1 Properties of different fats

According to Podmore (2002) and Marangoni (2002) different fats functionality in food is determined by their structural and crystalline properties. This can be seen in the manufacture of baked products. Most types of vegetable oil can be physically refined, modified by hydrogenation, interesterification and fractionation used singly or in combination. The costs relative to butter can be lowered by blending anhydrous milk fat (AMF) with vegetable oils while the preferred taste of butter is maintained (Danthine, 2012).

3.1.1 Crystallization behaviour

Fat and fatty acids exhibit polymorphism[3] and possess multiple melting points. Triglycerides occur in any one of three basic polymorphs: α, β’ and β. The α form is least stable and have the lowest melting point because it is the most loosely packed. The β’ form is more stable than the α form but irreversibly transforms to the β form. The β form has the highest melting point and is most closely packed. (Podmore, 2002; Lopez *et. al*, 2005; Metin and Hartel, 2005; Piska *et. al*, 2006; Pers. com., Persson, 2012)

The polymorphic state of the fat crystals as well as its microstructure and texture is affected by the cooling rate (Kaufman *et. al*, 2012). Rapid cooling gives the α form, which in slow heating melts to resolidify and give the β’ form. After further slow heating it melts and resolidifies in the β form (Podmore, 2002; Wiking *et. al*, 2009; Pers. com., Persson, 2012). In fats with a wide variety of molecular size and type of triglyceride the β’ form predominates because it is more able to accommodate the distortion of the chain packing necessary for a solid solution than the β form. Each triglyceride has it own polymorphic and melting be-

[3] the ability to exist in more than one crystalline form

haviour but in a mixture of triglycerides the individual triglycerides do not behave independently but take on a totally new character in terms of crystallization behaviour (Podmore, 2002). In a fat or fat blend at a given temperature there will always be a liquid phase and a solid phase, and the solid phase can have several components, which can change with temperature and composition (Podmore, 2002; Pers. com., Persson, 2012). Crystallization at 20°C below the melting point of the fat blend generally gives a good crystal distribution. A to high temperature gives large crystals with fluid channels and free oil (Pers. com., Persson, 2012). According to Podmore (2002) and Persson (Pers. com., 2012) the major features defining the firmness, texture and performance of a blended margarine and shortening are:

- the proportion by weight of crystals, which is governed by the solid-to-liquid ratio
- the melting point of the crystals
- the crystal geometry (size, shape and alignment)
- the degree of formation of mixed crystals
- the ability of the crystals to flocculate into a network which increases firmness

Smaller and finer β' crystals can stabilize more liquid component than can the larger and coarser β crystals (Podmore, 2002). The crystallization is initiated by nucleation in a supercooled system. In the manufacture of margarine and shortening the cooling rate, agitation and degree of supercooling control the rate of crystal growth and thus crystal size and crystal agglomeration, which affect the textural and melting properties of the fat product (Podmore, 2002; Pers. com., Persson, 2012).

3.1.2 Short pastry

Some of the functions of fat in bakery applications are lubricity, batter aeration, emulsifying properties and provision of flavour. The main ingredients in short pastry are flour, fat and water. When mixing flour and water the wheat proteins are hydrated to form gluten during the preparation of the dough. Wheat contains four classes of protein, based on solubility in certain solvents: albumins (water-soluble), globulins (dilute salt-soluble), glutenins (weak acid and alkaline soluble) and gliadins (soluble in aqueous alcohol). It is the glutenins and gliadins that provide the gluten of the wheat that gives rise to tough and extensible network in a flour-water dough. When a flour-water dough is baked it develops into a hard brittle texture. The function of the fat is to coat flour particles and so limit the extent of hydration by minimizing moisture ingress. The interruption in development of the gluten results in planes of weakness and so the product becomes "shorter" and more inclined to melt in the mouth. Too little fat will result in a tough and harsh eating pastry and too much will so interrupt the gluten development that the dough will be loose and soft to handle and too fragile when baked. The same comments apply when the shortening is too firm or too soft. A firm fat will not smear easily and will not distribute itself successfully in the dough to interrupt gluten development, which gives flinty product exhibition shrinkage. Liquid or fluid shortening leads to sloppy and soft and unworkable doughs. (Podmore, 2002)

In sweetened pastes sugar reduces the water availability and thereby reducing gluten development. The fat used should be one that can give good distribution during the minimum mixing time. Shortenings containing β and β' polymorphs perform well and give a good "short" texture and good mouth feel. Important is the ability of the fat to retain its plastic characteristics over a wide temperature range: realistically, 15-30°C, which is a function of the solid-to-liquid ratio of the fat blend. A relatively high proportion of triglycerides with three saturated fatty acids are needed so that a significant proportion of solid crystalline material is retained at higher temperatures. A high content of residual solid material could detract from the flavour. (Podmore, 2002)

3.1.3 Cake

Cakes are highly dependent on fat for proper aeration and the fat also contributes to crumb texture and mouth feel. The method of batter preparation has an influence on the distribution and fineness of the fat particle size in the batter. The finer the distribution of fat and air the better the final cake volume and crumb structure. In the creaming process there must be enough liquid oil available to envelope the air bubble, and sufficient crystalline fat to stabilize the system. The small β' crystals are the most effective in stabilizing air bubbles, as they can readily locate at the air-oil interface. Crystal aggregates that break up during the process can also stabilize the system. The proportion of crystalline triglyceride at the working temperature must be above minimum 5 %. An oil blend with a flat melting curve should be used to ensure there is sufficient crystalline material present through the baking process to stabilize the incorporated air. (Podmore, 2002)

3.2 Sensory analysis

The definition of sensory evaluation is according to Lawless and Heymann (2010):

> ”… a scientific method used to evoke, measure, analyze and interpret those responses to products as perceived through the senses of sight, smell, touch, taste and hearing.”

Peoples’ emotional judgments (preferences, attitudes, etc.) on the sensory properties are also included (Lundgren, 1981).

Sensory analysis can be divided into two different groups of tests in which there are sub-groups:

1. Analytical test
   a. Difference test (Discrimination test)
   b. Descriptive test
2. Consumer test (Hedonic test)
   a. Preference test (Affective test)

The division is made both by Lundgren (1981), by Meilgaard et al (1987) and by Lawless & Heymann (2010) and according to all of them further divisions can be made.

Sensory panel evaluation of food often combines the three methods. First, an analysis of whether there are differences is done. Then the nature and size of the gaps are analyzed. The last step is to determine how much consumers like the samples (Lundgren, 1981). The analysis of the data collected is a critical part of sensory testing and it should be analysed statistically (Lawless and Heymann, 2010).

3.2.1 Difference test

Difference tests decide if there are any sensory differences between samples or not. The three most common and equivalent methods, triangle test, paired test and duo-trio test all answers the question: Is there any difference – yes or no? (Lundgren, 1981; Lawless and Heymann, 2010). Difference test are usually performed when there are only two samples, multiple difference tests to compare more than two products are possible but it is not efficient or statistically defensible (Lawless and Heymann, 2010).

Difference tests are based on the doctrine of probability and the most common tests are paired test ($p=\frac{1}{2}$), duo-trio test ($p=\frac{1}{2}$) and triangle test ($p=\frac{1}{3}$). When the test is performed it is important not to inform the panel on issues that may affect their judgment (e.g. differences in the processing of the samples). The assessment is to be done from left to right and between the samples one should spit and rinse the mouth. This is important so that not one sample affects the next one. It is also important that the samples have the same temperature and volume/weight. Differences in volume/weight can give differences in colour, which in turn may affect the assessment (Pers. com., Albinsson, 2007).

When performing a difference test it is a risk that the wrong conclusion is drawn. Two types of error can occur (Table 8). Type II errors are often serious (expensive for the company). E.g. the company may lose market share through the implementation of product change perceived by the consumers but that the company thought they would not perceive as the own panel didn't perceive it. To minimize this risk, people who have as much probability as possible to detect differences in the product should be selected as reviewers. (Lundgren, 1981)

Table 8. Errors when analysing difference tests

Conclusion	Reality	Error
Difference	No difference	Type I
No difference	Difference	Type II

(Source: Lundgren, 1981)

A specially trained panel performs difference test, such a panel Lundgren (1981) calls a discrimination panel.

Albinsson (Pers. com., 2007) gives the following examples of application of difference tests:

- Will the product change if we change raw material/purveyor?
- Will the product have the same quality at both process lines?
- Can we change packing material with maintained quality?
- Is the product similar to the product of competitors?

3.2.2 Descriptive test

Descriptive tests are used after detected difference to describe the differences and how wide they are (Lundgren, 1981). The techniques allows the sensory scientist to obtain complete sensory descriptions of products, to identify underlying ingredient and process variables, and/or to determine which sensory attributes are important to acceptance (Lawless and Heymann, 2010). The assessors in this panel must be able to recognize differences and conduct assessments in a reproducible manner. They are specially trained and the panel is called a profile panel (Lundgren, 1981; Lawless and Heymann, 2010).

Lawless and Heymann (2010) points out that descriptive analyses are ideal in product development to measure how close a new introduction is to the target or to assess suitability of prototype products.

Albinsson (Pers. com., 2007) gives the following examples of uses of descriptive test:

- Follow how a product changes during storage
- Evaluate what differentiates the product from competing products
- Evaluate which properties that changes when the recipe is changed, or if a raw material/ingredient is changed.

3.2.3 Preference test

This type of test determines the consumers' appreciation for the product in a nine-point scale from "extremely dislike" to "liking extremely well". Then it is calculated which/what products the consumers prefer. The panel shall be representative of the target group of consumers with respect to age, gender, geographic location, etc. The assessors should not be trained in assessing the products and the panel is called a consumer panel. (Lundgren, 1981; Lawless and Heymann, 2010)

3.3 Evaluation

Both computerized and manual input of data can be used. The collected data are processed statistically to provide as much information about the samples as possible; however, it is important to remember that all methods have analytical errors. Mean and standard deviation is a minimum to calculate and a higher mean value does not always indicate a different between the samples, see Figure 1. (Pers. com., Albinsson, 2007)

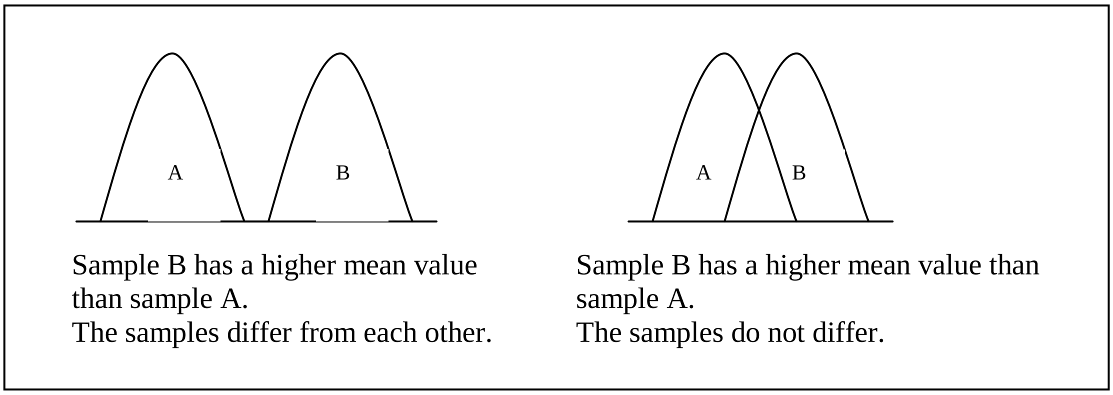

Figure 1 Difference or no difference at different mean values. (Source: Pers. com., Albinsson, 2007)

Descriptive statistics are used to effectively summarize and present data in tables or graphs. Hypothesis testing is used to determine whether differences in the data are random or not (Lundgren, 1981). The statistics can also provide evidence that the experimental treatment had an effect on the sensory properties of the product and that any differences observed between treatments isn't due to chance variation. It also estimates the degree of association between the variables (Lawless and Heymann, 2010). Multivariate data analysis makes it possible to create an overview of:

- Structure
- Similarity/dissimilarity
- Outliers

It also provides tools for:

- Classification
  - Recognising groups
- Modelling the relationship between Y and X
  - Not one x/y at a time, but all x's/y's simultaneously
  - Finding how the x-variables affect the responses
  - Finding how the x- an y-variables correlate to each other
  - How to set X to get the best profile of Y

(Umetrics, 2001)

3.3.1 Multivariate data analysis

In multivariate data analysis information are extracted from data with many variables using them all simultaneously. Data are collected to extract information and the type of data and its variability are important features as well as to present them in understandable form (Umetrics, 2001; Lawless and Heymann, 2010). Under stable conditions the variability stays within control limits, ±3 std.dev. All the variables are modelled together to find relationships between all the x's (inputs) and all the y's (outputs). Multivariate data analysis by projections deals with the dimensionality problem, handles many variables and few observations as well as few variables and many observations. Further it handles correlation, copes with missing data and is robust to noise in both X and Y. It separates regularities from noise, extracts information from all data simultaneously and the results are displayed graphically, which illustrate them clearly (Umetrics, 2001).

Partial Least Squares Projections to Latent Structures (PLS) is a tool in multivariate data analysis that helps to find relationships between sets of multivariate data X and Y. It also predicts one set from other for new observations x_i. PLS can be applicated for process modelling and optimization as well as multivariate calibration signals (spectra), which deals with concentrations, energy content, age, taste, and etcetera. The PLS-model is enabled to use as a causal model trough the use of design of experiments (DOE) and one can distinguish cause and effect. The graph obtained shows, which Y's is affected by which X's and in which direction. A line is drawn from an important y-variable and through (0,0) all x variables are than projected down on the line. The x-variables far out from origo are important and x:es on the same side as y have positive influence and those on the other side have negative influence (Umetrics, 2001).

Principal Component Analysis (PCA) is a multivariate technique that simplifies and describes interrelationships among multiple dependent variables and among objects. The PCA should be performed on the mean data and transforms the original dependent variables into new uncorrelated dimensions, which helps to interpret the data. The technique is very useful when several dependent variables are collinear. (Lawless and Heymann, 2010)

4 Results

4.1 Experiments at Pilot Plant

The two days conducted for experiments at pilot plant resulted in six different products packed in cups of 250 grams.

4.1.1 1st test drive – 12104

There were at start small problems with the cooling system but the test-drive went well as soon as it got started. All of the three products were fine, shiny and smooth on the original packaging. Hardness ranged from somewhat soft (12104-1) to very soft (12104-3). All three products landed near the desired values for salt content, fat content, water content and pH. They did not content yeast, mould or any bacteria over the choke limit. The chemical analyses showed that all the products softened from week three to week ten while the perceived hardness in the specialist panel were harder for 12104-3 and the reference product at week ten. In the sensory analyses (development panel) there were, after three weeks, seen weak errors in the spreadability of all products, in the hardness of product 12104-2 and 12104-3 and also weak errors in odour and flavour of the three pilot products and in butter taste in 12104-1. The appearance of the surface and the cut surface was assessed to fit the product description just as the saltiness of all the products and the buttertaste of all products except 12104-1. Distinct errors were seen in the hardness of 12104-1 and in the reference product. After ten weeks the spreadability of the products was somewhat better but still had weak errors, the hardness showed weak errors for 12104-1 and 12104-2 and distinct errors for 12104-3 and the reference product. The butter taste had weakened and was now assessed with weak errors applied to the product description. The specialist panel could not find any free water in the products after three weeks but found free water in 12104-1 and the reference product after ten weeks. 12104-2 melted in the same time as the reference product at week three while 12104-1 melted slower and 12104-3 melted faster. After ten weeks all three products melted faster than the reference product and also faster than after three weeks. The pilot products were perceived as less salty than the reference product and also as having slightly less acidity. Also the butter taste is perceived as lower in the pilot products than in the reference product. Differences in analyzed bacteriological, chemical and sensory values can be seen in Appendix 3 – Analysis 12104. The best results (based on the test bakings) were found for 12104-2 but a product that not softens as quickly without changing the proportion of butter oil/rapeseed oil in the fatty phase were desired.

4.1.2 2nd test drive – 12144

Problems with the cooling system resulted in that the experiment had to be carried out with fewer coolers than the first test drive. All of the three products were, however, easy to pack and they were fine, shiny, even and somewhat soft on the original packaging. 12144-2 was a bit too low in salt content and 12144-3 was a bit too high in the salt content, fat content and pH landed on the desired values for all the three test products. They did not content yeast, mould or any bacteria over the choke limit. The chemical analyses showed that 12144-1 softened from week three to week ten while 12144-2 and 12144-3 as well as the reference product hardened from week three to week ten. At the same time the sensory analyses in the specialist panel showed a small softening for 12144-2 and 12144-3 from week three to week ten and a hardening of 12144-1 and the reference product in this time. None of these changes were significant. In the sensory analyses (development panel) there were, after three weeks, seen weak errors in the appearance of the surface in 12144-2, in the appearance of the cut surface in 12144-2 and 12144-3, in the spreadabillity of 12144-2, 12144-3 and the reference product, in the hardness of 12144-1 and 12144-2 as well as saltiness and butter taste in 12144-1 and 12144-2. Distinct errors were observed in the hardness of 12144-3 and the reference product. All the other properties were assessed to fit the product description. After ten weeks all of the test products and the reference product were assessed according to the product description in appearance of surface (12144-1 showed weak errors), appearance of the cut surface, in water drop and in saltiness. Weak errors were seen in the spreadabillity of all the products, in the hardness of 12144-1 and 12144-2 and in the butter taste of 12144-3 and the reference product. Distinct errors were seen in the hardness of 12144-3 and the reference product as well as in the butter taste of 12144-1. The specialist panel found free water in 12144-3 after ten weeks and in the reference product after three weeks. All the three test products melted approximately in the same time, wich was faster than the reference product both after three and after ten weeks. The panel detected the lower salt content in 12144-2 but no significant differences were seen in the saltiness of the other products. The butter taste is perceived as lower in the pilot products than in the reference product. Differences in analyzed bacteriological, chemical and sensory values can be seen in Appendix 4 – Analysis 12144.

4.2 Properties of the baked products

4.2.1 1st test baking – reference products

Cinnamon rolls: The filling made with reference product 1 was relatively easy and smooth to stir. The fat was at the beginning somewhat hard but softens fast and became pliable. When baking with reference product 2 the fat was soft and smooth to stir together and the filling felt fluffy and light. The reference product 3 on the other hand was very hard and the filling was difficult and took long time to stir. Further the third filling was not as smooth as the other fillings.

Reference product 1's filling was easy to spread but the dough curled somewhat during the spreading. The spreading of the filling of reference product 2 was very easy but the dough was then hard to roll and cut as it both got stuck to the bench and to the knife. The third filling was hard to spread because the dough curled together but the rolling and cutting of the dough worked perfectly.

Shortbread: Reference product 1 was easy to work with through the whole process from preparation of the dough to the ready baked cookies. Reference product 2 was easy to work with at the dough preparation but hard to work with at the baking. The dough releases water, which made it difficult to cut as it sucked to the blade and burst. At the same time the dough softened all too fast which made it compress as it was cut, made it sticky and it got stuck in the cookie cutter when baking the rolled cookies. The dough with reference product 3 was difficult to work with during the preparation, as it tended to split, get sticky and got stuck in the table. Air pockets were also formed when the dough was rolled, which then contributed to cracking when the dough was cut. The dough was also very stiff and hard to stretch out in the beginning but once it was worked through once, it was very easy and flexible to work with.

Sponge cake: No major differences were observed between the different products.

The different observations can be seen in Appendix 5 – Observations at baking site. Overall reference product 1 was the easiest product to bake with. The results from the sensory evaluation of the baked goods can be see in Appendix 6 – Sensory results of baked goods and are being described further in chapter 4.3.3 Sensory evaluation of baked goods at page 34.

4.2.2 2nd test baking – Pilot products 12104-1, 12104-2 and 12104-3

Cinnamon rolls: All three products from the pilot plant were easy to make the filling from. The fillings were also easy to spread at the dough; however the dough got a bit difficult to roll.

Shortbread: 12104-1 and 12104-2 were easy to use in the preparation of the dough but they felt greasy/oily. 12104-3 gave too soft dough, which was difficult to form, and flowed out without sticking. Also this dough felt greasy/oily.

At the molding into cookies 12104-1 and 12104-2 still behaved equivalent. They were easy to cut and roll out but the dough became so loose that it was difficult to move the rolled cookies to the baking tray. 12104-3 had collapsed in the fridge because the dough was too loose, but it was easy to roll out and cut. However, the dough became too soft at the second and third roll out. The dough flowed out and the cookies became difficult to move to the baking tray, they did not keep their shape.

Sponge cake: No major differences were observed between the different products.

The different observations can be seen in Appendix 5 – Observations at baking site. Overall 12104-2 was considered to be the best of the products to bake with.

4.2.3 3rd test baking – Pilot Products 12144-1, 12144-2 and 12144-3 and also fractionated butter

Cinnamon rolls: The filling made with fractionated butter was relatively easy and smooth to stir. The fat was at the beginning somewhat hard but softened fast and became pliable. The filling was easy to spread but the dough curled somewhat during the spreading. The fractionated butter was equivalent to reference product 1. 12144-1 and 12144-2 were soft and smooth to stir and the fillings were easy to spread on to the dough. The dough stuck slightly in the baking board at the rolling. 12144-3 was slightly harder to stir the filling from, which then was easy to spread on the dough that was also easy to roll together and cut.

Shortbread: The fractionated butter was easy to work with both through the preparation of the dough and at the molding into cookies. 12144-1 and 12144-2 became a little too soft at the preparation of the dough while 12144-3 was easy to work with during the preparation of dough, as it was somewhat firmer than 12144-1 and 12144-2.

At the molding into cookies all of the three pilot products, 12144-1 to 12144-3, were easy to cut but 12144-3 had a small air pocket in the middle of the roll. The three doughs were also easy to roll out but because dough one and two were slightly too soft, the cookies were harder to move to the baking tray. 12144-3 was easy to move and was perceived as best to bake on of the three pilot products.

Sponge cake: No major differences were observed between the different products.

The different observations can be seen in Appendix 5 – Observations at baking site.

4.3 Sensory evaluation

The products from the pilot plant were as well as the three reference products sensory evaluated in different panels (specialist panel and development panel). The results were then analyzed in the Simca program. Also the baked goods were sensory evaluated and analyzed in Simca.

4.3.1 Sensory evaluation of lipid blends - specialist panel

12144-3 was closer to reference product 1 and reference product 2 than the other products (Figure 2). The analysis gave that lower pH and higher proportion of butterfat tended to give a saltier taste and more butter taste (see Figure 3 and 4). The taste of salt and butter was not affected of the fat content, the salt content or the water content (Figure 3 and 4). Lower salt content and pH-value also tended to result in a more elastic product, which can be seen in Figure 5. The elasticity of the product was not affected by the fat content, the water content or the distribution of vegetable fat and butter fat (Figure 5).

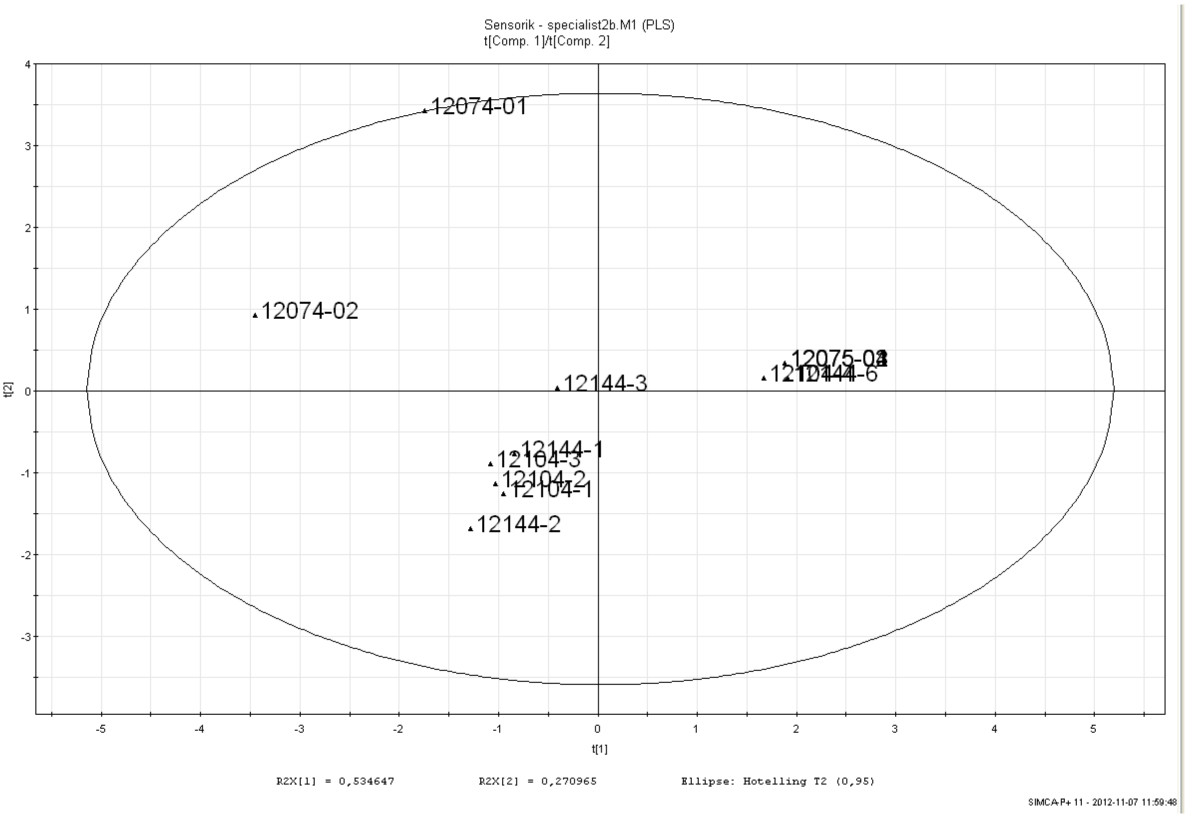

Figure 2 Positioning of the different products according to the specialist panel assessment, three and ten weeks.

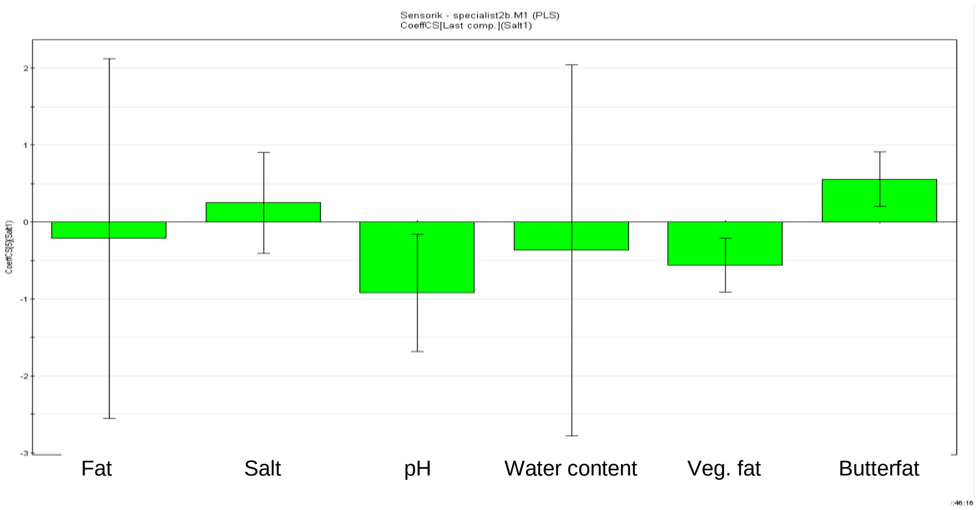

Figure 3 The impact of different factors on the tast of salt (all products included)

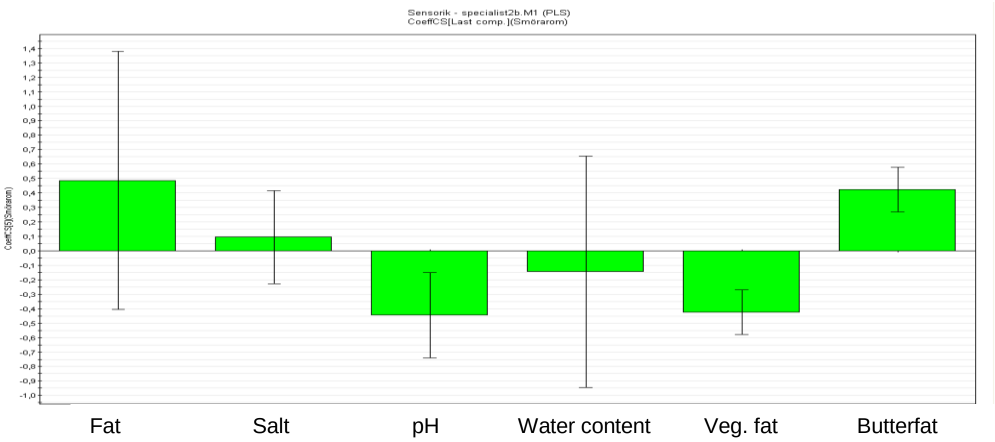

Figure 4 The impact of different factors on the butter taste

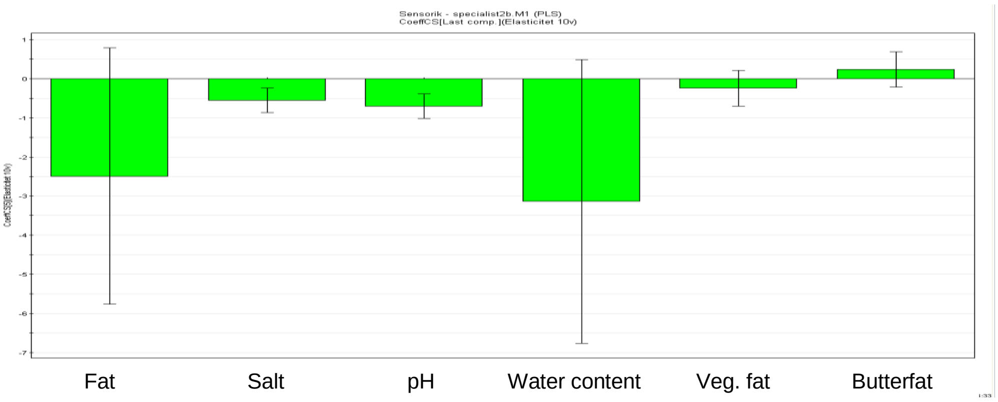

Figure 5 The impact of different factors on elasticity

The measured hardness at 8 respectively 14°C became higher at high temperatures of the pre-cooler and cooling sectors three in the perfector (Figure 6). It was not affected by fat content, salt content, pH, water content, temperature of the emulsion, the setting of the HTP (high pressure pump), temperature in cooler 1 and 2, the mixer, temperature at packing or the distribution of vegetable fat and butter fat (Figure 6). The connection was only seen after three weeks and not after ten weeks. The estimated hardness became higher at high pH, high temperature at packing site and at increased butterfat content, (Figure 7). The fat content, salt content, water content, the temperature of the emulsion, setting of the HTP, the temperatures of the pre-cooler or cooler 1-3 respectively or the mixer did not affect the estimated hardness (Figure 7). The product experienced as more elastic if the temperature in the emulsion phase was held low, if the HTP was low set and the temperature at one of the cooling sectors was high (Figure 8). None of the other settings (fat content, salt content, pH, water content, pre-cooler temperature, the temperature of the other coolers, mixer settings, temperature at packing site and distribution of vegetable fat and butterfat) affected the elasticity (Figure 8). The butter taste was increasing with the fat content and particularly with a high proportion of butterfat (Figure 9). Salt content, pH, water content, the different temperatures, settings of the HTP and the mixer had no effect on the butter taste (Figure 9). After ten weeks the butter taste was more prominent in products rich in salt and water.

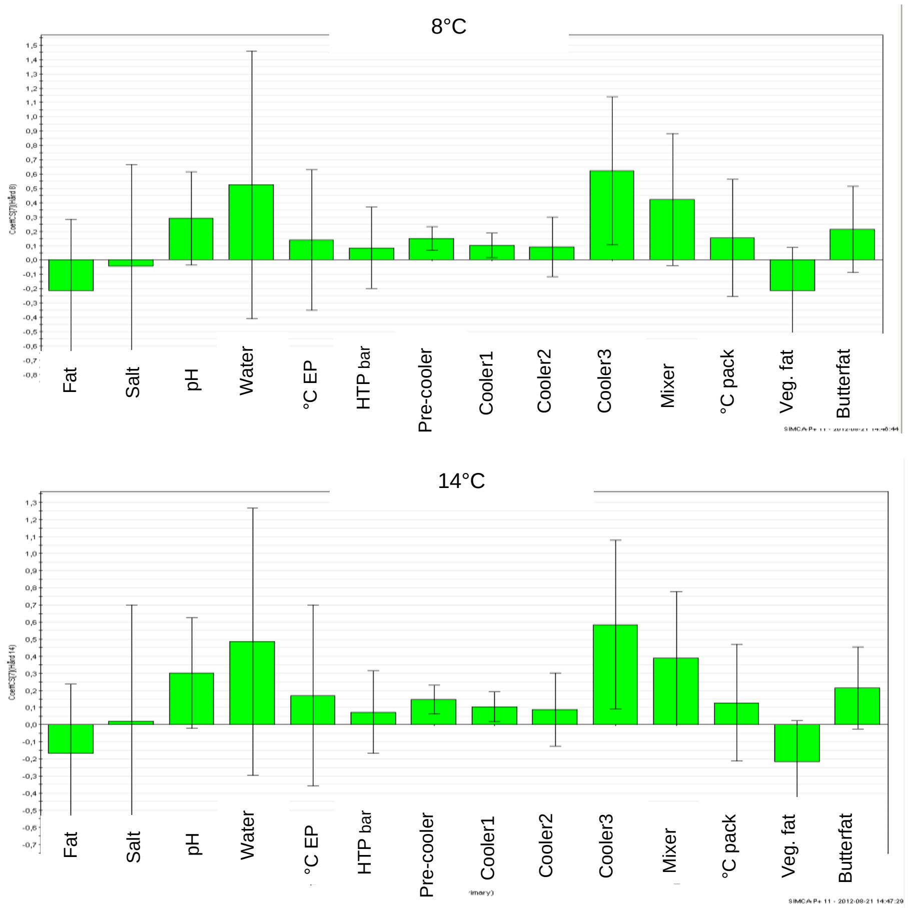

Figure 6 The impact of different factors on the measured hardness after three weeks
°C ECP = °C in the emulsion, HTP bar = pressure in the high pressure pump, °C pack = °C at packing

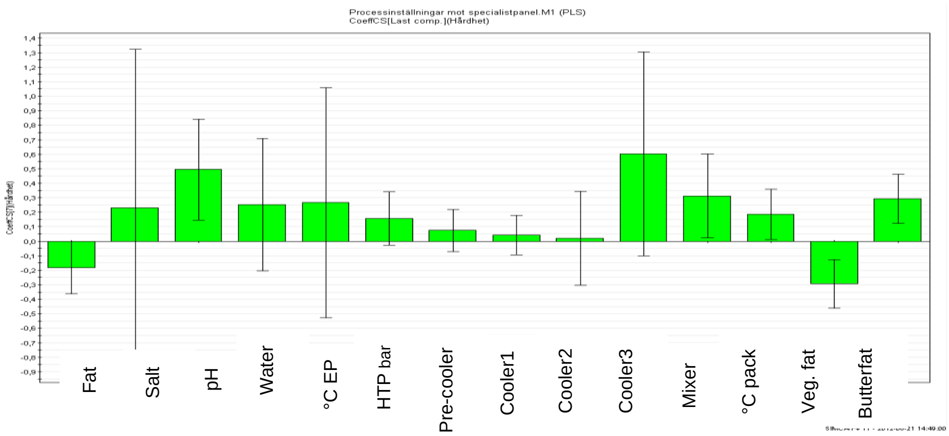

Figure 7 The impact of different factors on the estimated hardness

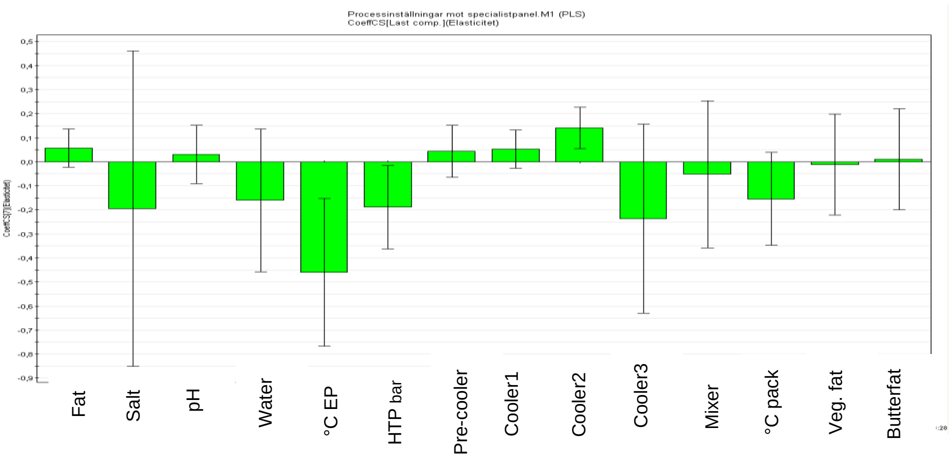

Figure 8 The impact of different process factors on elasticity

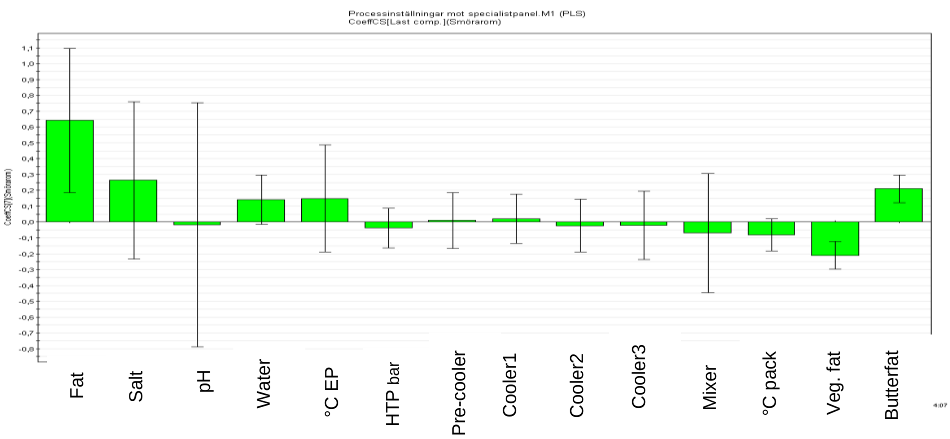

Figure 9 The impact of different process factors on butter taste

4.3.2 Sensory evaluation of lipid blends – development panel

High fat content gave better taste and surface appearance and higher water content gave rise to better hardness of the product, (Figure 10). The taste and surface appearance were not affected by salt content, pH or the distribution of vegetable fat and butterfat and the hardness was not affected by pH and the distribution of vegetable fat and butterfat (Figure 10).

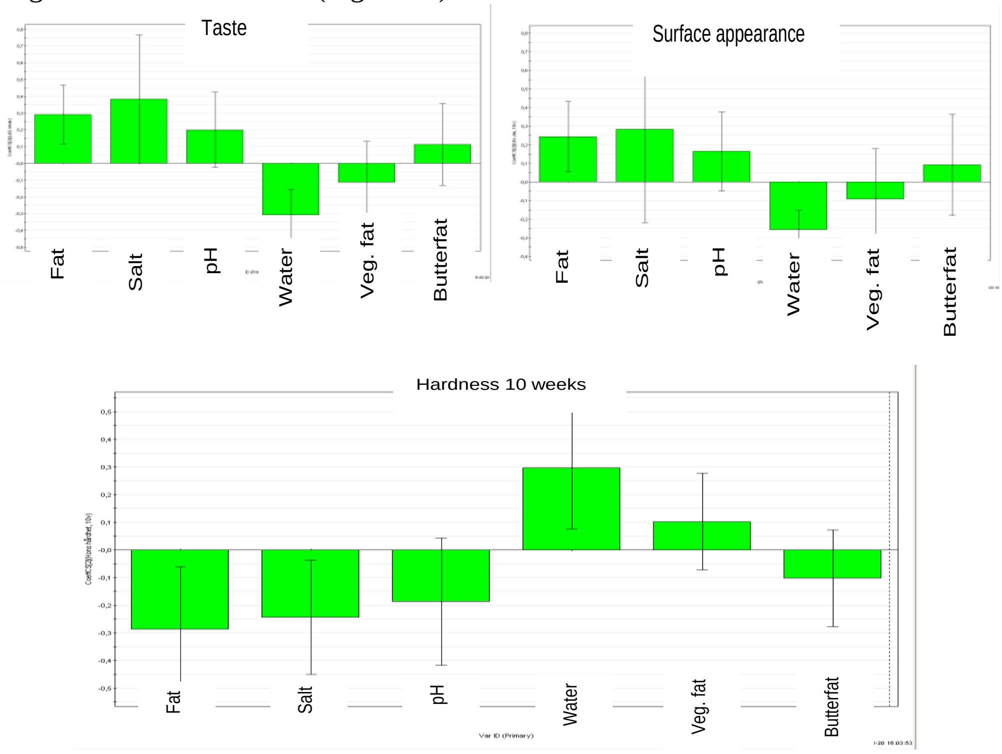

Figure 10 Different factors impact on taste, surface appearance and hardness of the product

4.3.3 Sensory evaluation of baked goods

Cinnamon rolls: High water content gave a smoother surface and more taste of flour.

Shortbread: The rolled cookies had no significance in butter taste (not shown) while the cut cookies tasted more of butter if the fat product had a higher salt content or a higher proportion of butterfat (Figure 11). Both low fat content and low water content gave rise to more colour at the surface and the low water content also gave rise to more sweet cookies, which at the same time tasted more of flour.

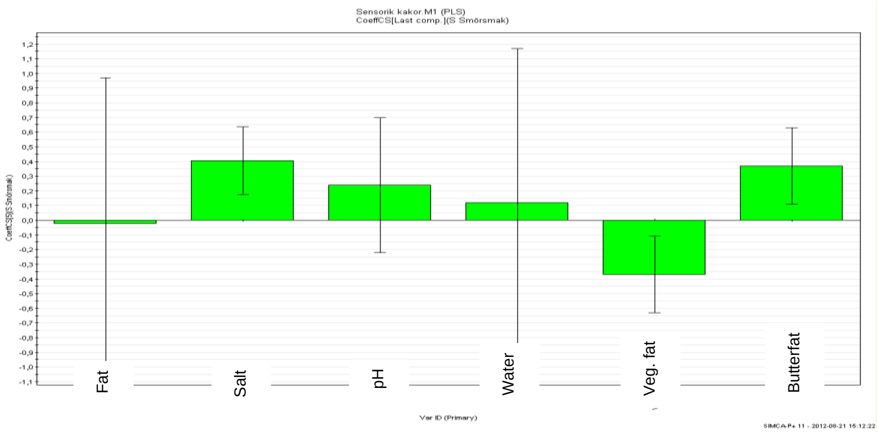

Figure 11 Different factors impact on the butter taste of cut cookies

Sponge cake: High fat content and high water content gave a richer butter taste (Figure 12). Lower content of fat and water gave richer colour both at the surface and the bottom and an airier cake (not shown).

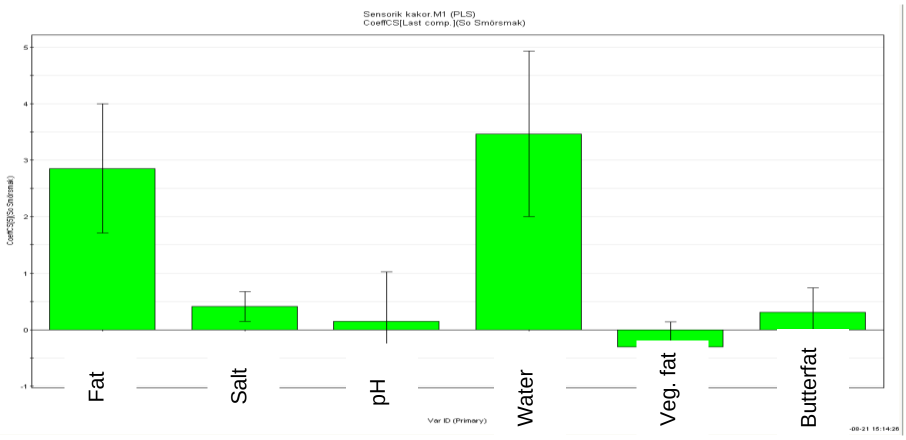

Figure 12 Factors affecting the butter taste of sponge cake

5 Discussion

5.1 Lipid blends and Baking properties

All three products from the first test drive at pilot plant (12104) were releasing oil. According to Persson (Pers. com., 2012) a too high temperature gives large crystals with fluid channels and free oil, which can be the reason to the problem as the first test drive had some problems getting cooled enough. The crystal structure also affects the melting properties of the product (Podmore, 2002; Pers. com., Persson, 2012) and the large crystals maybe melts faster because they are few. According to Podmore (2002) a too soft fat results in interrupted gluten development and thereby loose dough and fragile cookies. Both these properties were observed during the baking and at the sensory evaluation of the short bread made from the products of the first test drive at pilot plant. So: the products 12104-1 to 12104-3 contain large crystals which means that oil is released and the cookies gets crumbly.

Also the second test drive had problems with the cooling but this time the products were stronger cooled and thereby should more and smaller crystals have been formed. According to Persson (Pers. com., 2012) the crystallization temperature should be about 20 °C below the melting point to give a good crystal distribution. If the desired melting point is 35 °C the settings at the first test drive should give the best crystal structure while a desired melting point at 25 °C should give best results with the settings in the second test drive (see Appendix 1). Since a large percentage of solid fat can affect the taste negatively (Podmore, 2002) the melting curve should not be too flat. To some extent, an occurrence of taint can be recognised in the cookies made from reference product 1. Reference product 1 also had a significant larger proportion of solid fat at the higher temperatures (Figure 13).

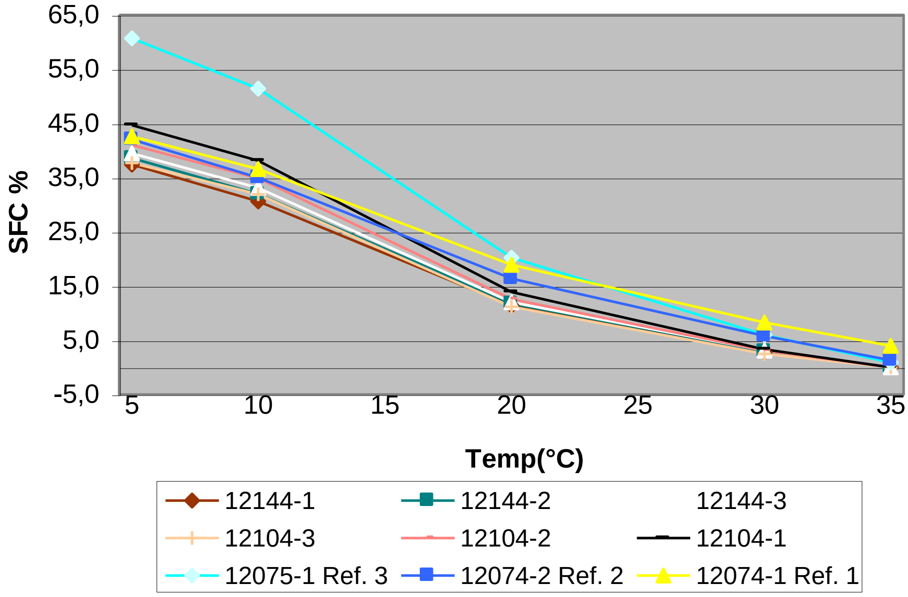

Figure 13 Solid fat content of the lipid blends at different temperatures

The settings at the second test drive gave a better distribution of the crystals at the same time as the fractionated butter helped to provide a good melting curve.

For the baking and the sensory characteristics of the sponge cake it did not seem to matter which fat to use. The airiness of the cake is according to Podmore (2002) affected by the proportion of crystalline material during the baking process because it stabilizes the air. However, this could not be seen, which is probably due to the fact that the cakes were baked with melted fat. When melting the fat in advance it cannot work as effective as it does when not melt through the baking process in the oven, as it should have done if it were put solid in the batter. The choice of method was made due to the simplicity of baking sponge cakes with melted fat, but instead the cakes should have been baked on solid fat whipped porous to get as much data as possible both through the baking process and from the finished cake.

5.2 Sensory evaluation

The results show that the product gets harder at higher temperatures in the manufacturing process. According to Persson (Pers. com., 2012) high temperatures give large crystals and according to Podmore (2002) the large β-crystals cannot stabilize as much oil as the smaller β'-crystals. Further the Podmore (2002) and

Persson (Pers. com., 2012) says that the β-crystals gives the hardest products, which agrees well with the results. After ten weeks, the relationship is not seen due to that products harden over time and the products that after three weeks were softer have had time to form large crystals. The differences in hardness between the products are thereby levelled out over time.

As expected, the butter flavour increased with increased fat percentage and increased percentage of butterfat. The butter flavour emerges even more in products with higher salt content, which may be due to the fact that salt is good at lifting and highlighting other flavours.

5.2.1 Sensory evaluation of baked goods

The butter flavour of the different baked goods was not significantly affected more than in the cut shortbread and the sponge cake. A richer butter flavour appeared if the fat were richer in salt (short bread), probably due to salt taste elevating properties, and at higher fat and water percentage (sponge cake). The relationship with a higher fat content might be due to the fact that products with higher fat content also gives more butter fat to the batter. Generally, it could be concluded that the percentage of butterfat not is decisive for butter flavour to the baked goods.

6 Conclusions and recommendations

None of the products from the experiments at Pilot plant were similar to reference product one, two or three, but the products form a new group. After all, 12144-3 was closer to reference product one than the other pilot products were. To get a product with the same characteristics as reference product one it is probably needed to fraction the fat or to ad stabilizer/emulsifiers. This in order to flatten the fat melting curve and particularly increase the proportion of solid fat at the higher temperatures. It is though important not to increase it too much so an odd flavour appears in the baked goods.

An analysis of the crystal structure in the product can be done to assure that the settings in the process give the desired structure. The recipe to further elaborate is the one for 12144-3 as it is approaching that of the product desired.

To assess the baking properties for sponge cake in a better way in which the opportunity to see more differences arise a recipe without melted fat should be chosen. Sugar and fat should be whisked porous instead of using melted fat because the ratio of solid fat and liquid fat is important to keep the air in the batter and so for the volume of the cake and also for the crumb structure.

No attempts to pack the product in foil have been made. Such experiments need to be carried.

List of references

ADAMS[4], 503.3.99 – Manual – TasteBOSS, Validity date 2005-04-08

ADAMS, 500.7.2.5-Smör och Bregott, Validity date 2010-09-08

Danthine, S. (2012) Physicochemical and structural properties of compound dairy fat blends. *Food Research International* 48, 187-195

Kaufman, N., Andersen, U. and Wiking, L. (2012) The effect of cooling rate and rapeseed oil addition on the melting behaviour, texture and microstructure of anhydrous milk fat. *International Dairy Journal* 25, 73-79

Lawless, H.T. and Heymann, H. (2010) Sensory evaluation of food – Principles and practices 2ed Springer, New York Dordrecht Heidelberg London

Lopez, C., Lesieur, P., Bourgaux, C. and Ollivon, M. (2005) Themal and Structural Behavior of Anhydrous Milk Fat. 3. Influence of Cooling Rate, *Journal of Dairy Science* 88, 511-526

Lundgren, B. (1981) Handbok i sensorisk analys. SIK-report no. 470. New printing 2000. Gothenburg: SIK – The Swedish Institute for Food and Biotechnology. ISBN: 91-7290-091-1

Marangoni, A. G. (2002) Special issues of FRI-crystallization, structure and functionality of fats. *Food Research International* 35, 907-908

Metin, S. and Hartel, R.W. (2005) Crystallization of fats and oils. *Bailey's Industrial Oil and Fat Products* 6, 45-76

Piska, I., Zárubová, M., Loužecký, T., Karami, H. and Filip, V. (2006) Properties and crystallization of fat blends. *Journal of Food Engineering* 77, 433-438 (Available online 26 September 2005)

Podmore, J. (2002) Bakery fats (30-68) in Rajah, Kanes K. (Ed). *Fats in food technology*. Sheffield Academic Press, Sheffield

Umetrics Academy (2001-11-22). Multivariate Data Analysis and Modelling. IID 1024

Wiking, L., De Grafe, V., Rasmussen, M. and Dewettnick, K. (2009) Relations between crystallisation mechanisms and microstructure of milk fat. *International Dairy Journal* 19, 424-430

Personal communication

Albinsson, Berit Sensory and Flavour Science at SIK – The Swedish Institute for Food and Biotechnology (16-17 January 2007)

Persson, Marcus Product and Technical Development Manager, AAK, Karlshamn (7-8 June 2012)

[4] The quality database of the dairy

Acknowledgement

Thanks to Pirjo Björkenbacke, Jan-Åke Larsson, Knut Junge for all help during the process working with this project. You have all made the work even more fun and interesting than I imagined when I started. Thank you for all your patience with me and my son. Thanks for all your inputs and good advice.

Götene 21 November, 2012

Appendix 1 – Process settings

Test umber	Temp. emulsion 1	volume	HTP[5] pressure	Pasteur temp. °C		Temp. preecooler °C 2		Temp. cooler °C 3		Temp. cooler °C 3		Temp. cooler °C 3		Mixer Rpm 4	Temp. °C 5	Appearance
	°C	liters	bar	product	water	product	water	product	NH_3^-	product	NH_3^-	product	NH_3^-		packing	in cup
arget alues	*int.*					*int.*	6	*high*		*int.*		*int.*		*int.*	*int.*	
2144-1	**int.**	**23**	**25**	**81**	**92**	**int.**	**6**	**low**	**-20**	**int.**	**-16**			**int.**	**high**	**Fine, shiny, smooth, somewhat soft**
2144-2	**high**	**15**	**27**	**81**		**int.**	**6**	**low**	**-20**	**low**	**-16**			**int.**	**high**	**Fine, shiny, smooth, somewhat soft**
2144-3	**int.**	**15**	**27,5**	**81**		**int.**	**6**	**low**	**-20**	**int.**	**-16**			**int.**	**high**	**Fine, shiny, smooth, somewhat soft**
2104-1	**int.**	**25**	**17**	**81**	**93**	**int.**	**2**	**high**	**-2**	**high**	**-2**	**int.**	**-2**	**int.**	**int.**	**Fine, shiny, smooth, somewhat soft**
2104-2	**int.**	**15**	**16**	**81**	**93**	**int.**	**2**	**high**	**-2**	**int.**	**-2**	**int.**	**-2**	**int.**	**int.**	**Fine, shiny, smooth, soft**
2104-3	**high**	**12**	**13**	**81**	**93**	**int.**	**2**	**high**	**-2**	**int.**	**-2**	**int.**	**-2**	**int.**	**int.**	**Fine, shiny, smooth, very soft**

	low	intermediate (int.)	high
1. Temperature of emulsion	40-50	51-60	61-70
2. Temperature of pree-cooler	20-30	31-40	41-50
3. Temperature of coolers	0-5,0	5,1-10,0	10,1-15,0
4. Rpm of mixer	0-150	160-300	310-450
5. Temperature at packningsite	0-5	6-10	11-15

[5] High pressure pump

Appendix 2 – Recipes of baked goods

Shortbread with egg

4 dl wheat flour (240 g)
200 g fat
½ dl sugar (45 g)
1 egg yolk

Brushing
1 beaten egg

Sponge cake

50 g fat
2 eggs
2 dl sugar (180 g)
3 dl wheat flour (180 g)
2 tsp baking powder (10 g)
2 tsp vanilla sugar (6 g)
1 dl water

Cinnamon rolls

150 g fat
5 dl milk
25 g yeast
½ tsp salt (3 g)
1¼ dl sugar (113 g)
about 1,3 l wheat flour (780 g)

Filling
100 g fat
1 dl sugar (90 g)
2 tsp cinnamon (5,4 g)

Brushing
1 beaten egg

Appendix 3 – Analysis 12104

Chemistry	AMF[1]/veg fat	12104-1	12104-2	12104-3	12104-4					
					Ref. 3					
		>X/<Y	***X/Y***	***<X/>Y***	***100/0***					
	Fat	x	x	x	x					
	Salt (%)	1,04	1,03	1,1	1,2					
	pH	6,06	6,14	6,18	6,2					
	Water content	z	z	z	z					
	Hardness 8°C, 3 weeks (gram)	407	335	274						
	Hardness 14°C, 3 weeks (gram)	218	182	140						
	Hardness 8°C, 10 weeks (gram)	325	323	265	503					
	Hardness 14°C, 10 weeks (gram)	157	148	123	283					

Bacteriology		12104-1	12104-2	12104-3	12104-4		12104-1	12104-2	12104-3	12104-4
		Fresh					**10 weeks**			
	Ba.cer (cfu)	<100	<100	<100	<100					
	Koli30 (cfu)	<10	<10	<10	<10					
	TOT (cfu)	800	100	<100	500		300	<100	<100	<100
	Yeast (cfu)	<10	<10	<10	<10		<10	<10	<10	<10
	Mould (cfu)	<10	<10	<10	<10		<10	<10	<10	<10

Sensory		3 weeks 8°C	12104-1	12104-2	12104-3	12104-4					
Develop.	**Appearance**	**Surface**	7,5	7,25	7,75	8					
		Cut surface	8	8	8	8					
	Consistency	**Water drop**	8	7,5	8	7,75					
		Spreadability	5,75	6,25	6,75	6					
		Hardness	4,75	5,5	6	5					
	Odour & flavour	**Saltiness**	8	8	8	8					
		Butter taste	7	7,75	7,5	8					
		Other	7,25	7	7	8					

1. AMF - Anhydrous milk fat = butter oil

		10 weeks	12104-1	12104-2	12104-3	12104-4
Sensory						
Develop.	Appearance	Surface	7,67	7,67	7,33	8
		Cut surface	8	8	8	8
	Consistency	Water drop	8	8	8	8
		Spreadability	6,33	6	6,33	5,67
		Hardness	6	5,67	5,33	5
	Odour & flavour	Saltiness	7,67	7,67	8	8
		Butter taste	6,67	6,67	7	8
		Other	6,67	7,67	7,67	7,67

		3 weeks	12104-1	12104-2	12104-3	12104-4
Sensory		8°C				
Specialist panel		Hardness	11,2	10,8	9	11,8
		Mattiness	10	9,2	7,8	12
		Sliceness	0	0,2	0	0,2
		Continuous	9,8	9	10,4	9,6
		Homogeneous	10,6	10,6	10,8	10,4
		Aeration	0,6	0,2	0	0
		Free water	0,2	0	0	0,8
		Melting	9,8	9,6	8,4	9,6
		Saltiness	6,2	5,6	5,6	7
		Acidity	2	2	2,2	2,6
		Butter taste	4,2	4,6	4,4	8

		10 weeks	12104-1	12104-2	12104-3	12104-4
Sensory		8°C				
Specialist panel		Hardness	10,75	9,75	9,75	14,5
		Mattiness	9,5	8,75	8,5	12
		Sliceness	0	1	0	3,75
		Elasticity	3,03	3,79	4,21	4,18
		Continuous	5,75	6,75	7,25	10
		Grainy	1,48	1,63	0,96	1,9
		Aeration	0	0,5	0	0,75
		Free water	4	0,25	0	5,75
		Melting	8,25	7,75	7,25	8,75
		Saltiness	6,5	6	6,25	7,75
		Acidity	3	3	3,25	4,5
		Butter taste	5,25	5,5	5,75	8

Appendix 4 – Analysis 12144

			12144-1	12144-2	12144-3	12144-6				
						Ref. 3				
Chemistry		AMF/veg fat	***x/y***	***x/y***	***x/y***	***100/0***				
		Fractionated fat	***>a***	***a***	***<a***					
	Fat		x	x	x	x				
	Salt (%)		1,05	0,42	1,62	1,18				
	pH		6,03	6,09	6,03	6,34				
	Water content		z	z	z	z				
	Hardness 8°C, 3 weeks (gram)		200	218	230	316				
	Hardness 14°C, 3 weeks (gram)		87	97	114	114				
	Hardness 8°C, 10 weeks (gram)		181	230	265	406				
	Hardness 14°C, 10 weeks (gram)		87	127	112	197				

			12144-1	12144-2	12144-3	12144-6	12144-1	12144-2	12144-3	12144-6
Bacteriology			Fresh				10 weeks			
	Ba.cer (cfu)		<100	<100	<100	<100				
	Koli30 (cfu)		<10	<10	<10	<10				
	TOT (cfu)		200	<100	100	400	800	100	<100	<100
	Yeast (cfu)		<10	<10	<10	<10	<10	<10	<10	<10
	Mould (cfu)		<10	<10	<10	<10	<10	<10	<10	<10

			12144-1	12144-2	12144-3	12144-6				
		3 weeks								
Sensory		8°C								
Develop.	**Appearance**	**Surface**	8,00	7,33	8,00	7,67				
		Cut surface	8,00	7,33	7,33	8,00				
	Consistency	**Water drop**	8,00	8,00	8,00	8,00				
		Spreadability	8,00	6,67	6,33	6,33				
		Hardness	7,33	6,33	5,33	5,33				
	Odour & flavour	**Saltiness**	7,33	6,00	7,67	8,00				
		Butter taste	7,33	7,00	7,67	8,00				
		Other	6,67	6,00	6,67	8,00				

		10 weeks	12144-1	12144-2	12144-3	12144-6				
Sensory										
Develop.	**Appearance**	**Surface**	7	7,5	8	8				
		Cut surface	7,5	8	7,5	8				
	Consistency	**Water drop**	8	8	8	8				
		Spreadability	7	6,5	6,5	6,5				
		Hardness	7	6	5	4				
	Odour & flavour	**Saltiness**	8	7,5	8	8				
		Butter taste	5	6	7	7				
		Other	4	5	7	7				

		3 weeks	**12144-1**	**12144-2**	**12144-3**	**12144-6**				
Sensory		**8°C**				**Ref. 3**				
Specialist panel		**Hardness**	8	8,14	10	12				
		Mattiness	2,14	1,86	2,43	0				
		Sliceness	6	6,57	7,71	13,43				
		Elasticity	2,14	0	0	0				
		Continuous	8,43	7,43	6,43	9,57				
		Grainy	10,43	11,57	9	10,71				
		Aeration	1,86	2,43	2,29	2,29				
		Free water	0	0	0,14	2				
		Melting	6,71	7,57	8,43	10,14				
		Saltiness	5,86	3,43	5,86	6,86				
		Acidity	2,43	2,29	3,14	3,86				
		Butter taste	4	4	5,14	7,29				

		10 weeks	**12144-1**	**12144-2**	**12144-3**	**12144-6**				
Sensory		**8°C**				**Ref. 3**				
Specialist panel		**Hardness**	8,5	8	9	13,75				
		Mattiness	1,25	0,25	0	0				
		Sliceness	6,75	7,25	8,75	13,25				
		Elasticity	1,5	0,25	0,25	0				
		Continuous	5,5	6,5	3	3,5				
		Grainy	10,5	11	9,25	10,5				
		Aeration	1,75	1,25	2	4,75				
		Free water	0	0	2	0,75				
		Melting	7	7,75	7,5	12				
		Saltiness	6,75	3	7,5	6				
		Acidity	3,25	2,5	4,5	4,25				
		Butter taste	3,5	2,25	4,5	7,75				

Appendix 5 – Observations at bakingsite

Baking		12074-1 Ref. 1	12074-2 Ref. 2	12075-1 Ref. 3	12104-1	12104-2	12104-3	12104-4 Ref. 3	12144-1	12144-2	12144-3	12144-6 Ref. 3
Shortbread preparation	Time to smooth dough (s)	30	18	34	28	19	15	35	14	12	16	26
	Rolling[1]	3	3	1	3	3	3	2	2	2	3	3
	Stuck in the bench[2]	3	3	2	3	3	4	2	3	3	4	4
	Sticky surface[3]	4	3	2	2	2	2	3	3	3	3	3
Shortbread Cut	Cut the rolls[4]	3	1	2	3	3	4	2	3	3	4	2
	Brush with egg (1= hard, 2= easy)	1	2	2	2	2	2	2	2	2	2	2
Rolled	First stretching[5]	3	3	1	2	2	3	1	3	3	3	1
	Later stretchings[5]	3	3	3	4	4	4	3	4	4	4	3
	Adhesion of the plastic[6]	2	1	3	2	2	2	3	2	2	2	3
	Transfer to baking tray[7]	3	3	4	2	1	1	4	3	2	3	4
	Shape in oven[8]	2	2	2	3	3	3	3	3	3	3	3

1. Scale for rolling: 1 = cracks much, 2 = form small cracks/air pockets, 3 = keep up, smoth and fine

2. Scale for stuck in the bench: 1 = stuck and can not get loose, 2 = stuck, can loosen with a knife, 3 = stuck, can easily loosen, 4 = Does not stick to the bench

3. Scale for sticky surface: 1 = very sticky, 2 = sticky, 3 = somewhat sticky, 4 = not sticky

4. Scale for cut the rolls: 1 = very difficult to cut, 2 = difficult to cut, 3 = easy to cut, 4 = very easy to cut

5. Scale for stretching: 1. = Very hard/difficult to stretch, 2. Hard or sticky / difficult to stretch, 3 = Soft/easy to stretch, 4 = Very soft/easy to stretch

6. Scale for adhesion of the plastic: 1 = strong adhesion, 2 = weak adhesion, 3 = no adhesion

7. Scale for transfer to baking tray: 1 = very difficult to transfer, 2 = difficult to transfer, 3 = easy to transfer, 4 = very easy to transfer

8. Scale for shape in over: 1 = floats out, big difference, 2 = floats out, small difference, 3 = keeps the shape

Baking		12074-1 Ref. 1	12074-2 Ref. 2	12075-1 Ref. 3	12104-1	12104-2	12104-3	12104-4 Ref. 3	12144-1	12144-2	12144-3	12144-6 Ref. 3
Cinnamon rolls	Time to cook (min)	3,5	3,5	2,5	3,5	3,25	3,3	3,5	3,5	3,8	4	3,25
Fat melting	Total melt time (min)	6	4,75	4,5	5	4	3,6	5,6	4	4,3	4	5,5
	Spattering (number of drops)	0	10	44	7	0	0	37	0	0	0	42
Dough	Flour use (g)	732	780	741	715	753	755	722	731	726	735	712
	Fermentation in bowl[9]	1	2	3	3	4	4	3	4	5	5	5
	Spreading the filling[10]	3	4	2	5	5	5	2	3	3	3	2
	Curling of the dough[11]	3	4	2	4	4	4	2	4	4	4	2
	Stirring of the filling[12]	3	5	1	3	3	4	1	5	5	3	2
	Rolling and cutting the dough[13]	4	1	5	3	3	3	5	3	3	5	5
	Fermentation on baking tray[9]	1	2	3	3	5	4	3	5	4	5	3
	Rendering of fat[14]	3	3	2	3	3	2	2	3	3	3	3

9. Scale for fermentation: 1 = very poor fermentation, 2 = poor fermentation, 3 = okej fermentation, 4 = good fermentation, 5 = very good fermentation

10. Scale for spreading the filling: 1 = very hard to spread, 2 = hard to spread, 3 = easy to spread, 4 = very easy to spread

11. Scale for curling of the dough: 1 = excessive curling, 2 = curling, 3 = tendency of curling, 4 = no curling

12. Scale for stirring of the filling: 1 = very difficult, 2 = difficult, 3 = neither easy nor difficult, 4 = easy, 5 = very easy

13. Scale for rolling and cutting the dough: 1 = very difficult to cut and to roll, 2 = difficult to cut and to roll, 3 = difficult to cut or to roll, 4 = easy to cut and to roll, 5 = very easy to cut and to roll

14. Scale for rendering of fat: 1 = much, clearly visible, 2 = some, visible, 3 = none, not visible

		12074-1	12074-2	12075-1	12104-1	12104-2	12104-3	12104-4	12144-1	12144-2	12144-3	12144-6
Baking		**Ref. 1**	**Ref. 2**	**Ref. 3**				**Ref. 3**				**Ref. 3**
Sponge cake	Volume (dl)	12	11,75	11	12,2	11,6	11,2	11,2	11,4	10,9	10,8	
	Hight (cm)	4,8	4,7	4,5	5,8	5,2	5	4,9	5	5,2	5,3	
	Time in oven (min)	40	40	40	40	40	41	40	40	40	40	
	Easiness to turn out the cake[15]	4	1	2	2	2	2	4	2	2	2	

15. Scale for easiness to turn out the cake: 1 = very difficult, 2 = difficult, 3 = easy, 4 = very easy

Appendix 6 – Sensory results of baked goods

Sensory - baking			12074-1	12074-2	12075-1	12104-1	12104-2	12104-3	12075-1	12144-1	12144-2	12144-3	12144-6
			Ref 1	Ref 2	Ref 3				Ref 3				Ref 3
Short bread Rolled	Appearance	Color upper surface	4,98	4,30	6,85	3,84	6,92	4,67	7,95	5,44	6,71	2,53	11,72
		Color lower surface	6,98	4,61	7,32	5,03	7,14	6,02	7,9	6,09	7,22	3,29	10,87
	Consistency	Brittleness	9,4	10,15	8,71	9,06	9,29	11,14	10,77	8,86	10,36	8,52	10,88
	Odor & flavor	Sweetness	4,27	3,86	7,9	5,18	6,61	6,39	6,02	6,67	8,02	5,78	7,07
		Taste of flour	5,4	5,77	3,88	7,07	7,41	6,47	8,34	8,37	7,64	5,65	7,48
		Butter taste	2,79	3,13	7,46	5,46	6,53	6,98	6,83	5,29	3,75	4,73	7,73
Short bread Cut	Appearance	Color upper surface	7,49	4,81	9,7	5,27	6,23	6,3	5,87	5,92	5,05	7,42	8,11
		Smoothness	7,57	12,29	4,71	10,35	8,26	8,55	5,85	9,15	7,92	8,42	5,66
		Color lower surface	7,48	5,07	8,28	4,56	3,34	3,58	2,36	4,88	4,17	6,28	6,52
	Consistency	Brittleness	9,37	8,84	10,81	8,79	9,51	10,26	10,95	8,8	9,44	8,9	9,27
	Odor & flavor	Sweetness	6,47	5,64	6,49	5,16	3,27	4,34	4,49	6,03	5,29	6,79	8,47
		Taste of flour	5,1	5,41	3,4	8,11	7,22	10,65	6,84	5,64	8,38	6,21	4,16
		Butter taste	1,67	1,94	6,94	7,25	6,34	4,16	6,91	5,03	2,66	5,9	7
Cinnamon rolls	Appearance	color upper surface	6,67	8,54	8,8	4,49	8,69	8,63	7,17	9,28	6,47	7,64	7,33
		Smoothness	11,25	12,52	10,55	12,1	11,52	11,93	12,37	8,7	8,79	9,14	8,52
		Color lower surface	8,18	8,66	10,7	9,18	10,15	9,46	9,47	9,52	9,45	9,34	9,26
	Consistency	Aeration	5,95	6,5	9,82	7,11	8,32	9,17	8,82	8,92	8,39	9,09	7,7
		"Moisture"	6,88	9,42	6,91	8,73	6,47	8,59	8,99	8,34	8,31	7,71	8,21
	Odor & flavor	Sweetness	6,75	8,55	7,79	7,4	7,03	8,31	6,53	7,26	7,44	7,45	6,98
		Taste of flour	2,55	2,54	2,43	5,98	4,88	5,5	7,37	2,8	4,18	4,32	3,95
		Butter taste	2,17	4,52	8,97	6,12	6,97	8,13	6,41	6,96	6,09	6,22	4,29
Sponge-cake	Appearance	color upper surface	7,72	6,99	8,75	7,85	7,23	7,41	7,82	8,07	6,61	7,46	
		Color lower surface	7,23	5,83	8,35	6,82	7,3	7,64	7,14	7,83	7,6	8,02	
	Consistency	Aeration	8,03	7,75	7,36	8,95	8,13	7,52	5,43	8,34	10,31	10,36	
	Odor & flavor	Sweetness	6,29	7,05	7,55	7,92	8,21	6,86	8,38	9,29	7,97	7,76	
		Taste of flour	3,78	4,49	4,71	6,04	6,31	5,31	6,33	5,1	5,98	2,9	
		Butter taste	2,9	4,82	4,15	7,58	7,46	6,51	7,99	5,85	4,7	5,77	

Summary

Today the consumers' interests in natural products are increasing. At the same time the milk fat is getting more and more expensive. The combination result in that a dairy food company wants to offer consumers a natural blended spread product without additives but with the excellent butter flavour maintained.

A project to develop a recipe for such a product has been carried out at the dairy. Based on the literature and the company's collective knowledge of the properties of fats production in small-scale plant for testing of six different recipes was made. Also time for sensory, chemical and bacteriological assessments of the products produced and test baking with the products were performed. The analysis were made after three and also after ten weeks because the taste of butter is developing over time and fats also hardens with time and the shelflife time was to be set to ten weeks. The results from the different experiments were analysed statistically by multivariate data analysis.

Six different fats were produced, analysed and baked with together with three reference products with different desired properties. The baked goods were shortbread (both cut and rolled), cinnamon rolls and also sponge cakes. To get a precise result all the ingredients were weighed just like the dough for each cinnamon roll for example.

In the first day of small-scale production three different recipes with varied ratio of milk fat/vegetable fat were tried. The products were found to be leaking oil probably due to high temperatures during the process. This made these fats difficult to bake with as also the dough got oily and soft and the shortbreads got crumbly. Cinnamon rolls and sponge cakes were easy to bake and no major differences were seen between the products. The fats were though getting too soft too soon when handled and therefore the second tryout's recipes contained different ratios of fractionated butter[1]. That together with lower temperatures in the process gave the fat a better melting curve and no free oil was leaking from the products. It also resulted in fats that were easier to bake shortbreads from.

The result of the project is a product recipe for the dairy to work further with to see if the product is to pack in foil.

Keywords: butter flavour, hardness, fat

[1] Butter divided into fractions with different melting points, the fractions giving desired melting properties are used